PM and Precursor Emissions from Distributed Generation in Combined Heat and Power Applications

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Summary

There are a number of potential advantages of distributed (co)generation of electricity, including enhanced reliability, avoidance of transmission and distribution upgrades and cost savings by avoiding power purchases during peak periods. However, the key advantage to distributed (co)generation is that on-site production of electricity allows combined heat and power (CHP) applications, with resulting overall generation efficiencies of over 80%. However, on-site power generation has raised concerns over the impacts of widespread fossil DG use on local air pollution, particularly nitrogen oxides (NO_X), carbon monoxide (CO), particulate matter (PM10) and hydro-carbons (HC). This paper compares five DG-CHP technologies (diesel ICE, natural gas ICE, micro-turbines, fuel cells and gas turbines), to two centralized technologies (coal steam turbines and combined cycle gas turbines [CCGT]) together with on-site heat boilers. A key parameter of comparison is the heat to power ratio (HPR) of demand. Technologies are compared from an HPR = 0 (electricity-only applications), to an HPR = 3 (heat dominated system).

A detailed energy technology analysis finds DG-CHP technologies are generally cost competitive with centralized electricity generation and on-site heat production. When considering current emission-controlled base-load units, DG-CHP technologies have significant emissions advantages on an output basis over a range of electricity and heat demands. Some DG-CHP technologies (micro-turbines and fuel cells) are generally superior over the majority of HPR values, for others (gas ICE) significant heat demands are required, and still others (diesel ICE) struggle against efficient CCGT plant. If the comparison is with coal steam turbines, the advantages of DG-CHP are magnified.

However due to the considerable variation in electricity and heat demands (HPR), the impacts of input parameters (generation efficiencies and emission factors), various customer classes by demand density, and various vintages of technology, this comparison suggests technologies should be compared on a case-by-case basis. This paper can serve as a starting point for these individual evaluations.

It is important to realize that the results presented here flow naturally from the conditions we assumed, including the use of current-generation technologies. Importantly, these assumptions include the use of DG-CHP units *with* emission controls currently available on the market, and in many places, required to obtain an air quality permit. In addition, the successful experience of DG-CHP technologies in the Netherlands where they are centrally dispatched and centrally monitored suggests that current sensor and IT technologies might make it feasible to include DG-CHP generators in unit-specific regulation such as a cap-and-trade program. However, requiring DG-CHP units to attain the level of accuracy and reliability that Continuous Emission Monitors (CEMs) must reach for central station power plants would probably be economically infeasible. Designing a cost-effective approach to this problem is an important research issue.

Finally, here we have only estimated emissions across technology types. In order to completely understand the public policy issues at hand, further work is needed to develop scenarios for estimating regional emissions inventories and conducting air quality modeling. The research presented here provides some basis for such work, and it also shows that one cannot dismiss DG-CHP technologies based on concerns about air quality without.